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The Application of Nonmarket Valuation Techniques to Agricultural Issues

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The Application of Nonmarket Valuation Techniques to Agricultural Issues. By Joseph C. Cooper. Natural Resources and Environment Division, Economic Research Service, U.S. Department of Agriculture. AGES 9503.

Abstract

Nonmarket valuation techniques can be used to examine the relationship between agricultural practices and the environment. This report provides theoretical descriptions of the most popular nonmarket valuation techniques, which are the travel cost method and the contingent valuation method. In addition, several case studies of applications with agricultural implications are presented.

Keywords: Travel cost method, contingent valuation method, agriculture

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Introduction

This report demonstrates how nonmarket valuation techniques can be used to examine the relationship between agricultural practices and the environment. While a few contemporary literature reviews of nonmarket valuation techniques, such as the travel cost method (TCM) and the contingent valuation method (CVM), have mentioned that these techniques can be applied to agricultural issues, these reviews have not demonstrated how to perform these applications. Knowledge of how to use these methods would be especially useful to researchers interested in measuring the welfare implications of externalities generated by agricultural activities.

Though both CVM and TCM can sometimes be used to value the same goods, TCM is based on observed behavior and is applicable to a narrower range of issues than CVM. The more limited applicability of this demand estimating technique results from its being based on observed market data. CVM is a market simulation approach that uses direct consumer surveys. CVM has been criticized for providing unrealistic values in many situations. However, its use has been recently validated as long as approved guidelines are followed (Department of Commerce, 1993). CVM is the most widely utilized procedure for determining the value of nonmarket goods in cases where TCM cannot be used.[1] In particular, dichotomous choice CVM has been shown to produce benefits estimates close to the true benefits (Bishop and Heberlein, 1979) and has been shown to be reliable in re-testing (Loomis, 1989), at least for user values (as opposed to option, existence, or bequest values).[2]

One possible use of these benefit estimates is in benefit-cost analysis (Freeman, 1979). Under this criterion, for example, if the cost of decontaminating a site to meet some standard exceeds the benefits to consumers of attaining this standard, then this site would not be decontaminated. Instead, clean-up funds could be better allocated to projects with higher benefit-cost ratios.

There are numerous reasons why these techniques are applicable to agricultural issues. Among them, agricultural activities produce both costs and benefits that may not be priced in the marketplace. In another application, some government agricultural programs not yet initiated may have an unknown cost that cannot be surmised from market activity. For example, CVM can be used to determine the optimal payment to farmers to induce them to put in filter strips or other long-term set-aside acreage or to undertake integrated pest management activities.

In many cases, it may be possible, or necessary, to estimate the benefits or costs of a nonmarket activity without conducting an original survey. Surveys are relatively expensive to conduct, and many goods need to have their market values assessed. With funding for surveys becoming increasingly scarce, examining procedures for transferring benefit values from existing studies to new study sites becomes increasingly important. Because an understanding of how benefit values are estimated is necessary to successfully transfer them, this report is also useful to those who plan to use results from existing studies.

This report will first provide theoretical descriptions of the most popular nonmarket valuation techniques, which are the travel cost method and the contingent valuation method. Next, several case studies of applications with agricultural implications are presented. The TCM case studies are: 1) an examination of the effects of agricultural activities on waterfowl hunting benefits in the Kesterson National Wildlife Refuge; and 2) a comparison of the value of water in recreational uses versus agricultural uses in California's San Joaquin Valley. The CVM case study addresses the minimum level of incentive payments to encourage farmers to use environmentally sound management practices.

This document is intended for two audiences. A general exposition and discussion of nonmarket valuation techniques is provided for the lay reader who wants a basic understanding of the methods used in valuing or determining the benefits of nonmarket activities. In the appendices, a more technical exposition is provided for the more advanced reader. These sections will be noted and may be skipped by the nontechnical reader without loss of an understanding of basic valuation approaches.

Definition of Benefits

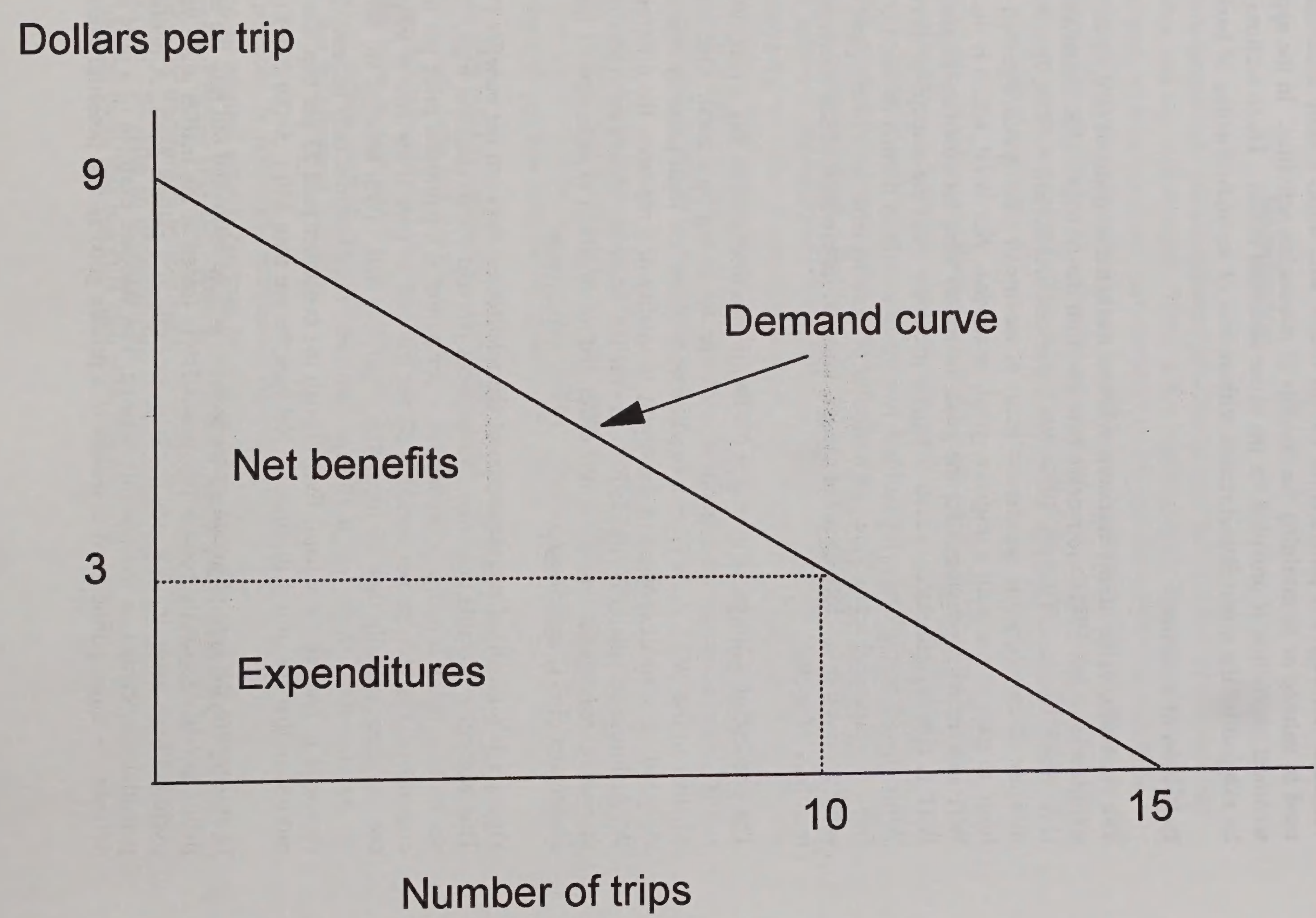
The economic value of any resource, whether marketed or nonmarketed, is defined as the user's willingness to pay (WTP) to receive benefits from the resource (U.S. Department of the Interior, 1986; U.S. Water Resource Council, 1979, 1983; Sassone and Schaffer, 1978; Just, et al., 1982). WTP is a measure of the economic sacrifice in terms of income or other goods a person is willing and able to forgo to gain or maintain a resource, good, or service. Net WTP, which is the difference between WTP and actual expenditures for the good, is usually used for cost-benefit analysis. Whether this WTP is actually collected as cash is largely irrelevant from the standpoint of economic efficiency. While it may be important for political reasons to transfer a portion of the user's WTP to actual cash flow, any financial returns are just a transfer of benefits from user to recipient. The total economic value received by society does not change, only the distribution of the economic value among members of society.

The concept of willingness to accept (WTA) is also discussed in this report. WTA is the willingness to accept either income or other goods in exchange for giving up a good. One criterion for selecting whether to use WTA or WTP is a function of who has the legal property rights to the existing level of the good. For small changes in the supply or quality of a resource, the difference between WTP and WTA should be small (Willig, 1976). In practice, however, these two values often diverge. For theoretical reasons for why they may differ and an empirical examination of the differences, see Hanemann (1991) and Shogren, et al. (1994), respectively.

Figure 1 is a graphical representation of the relationship between net benefits (WTP) and expenditures. This particular example describes a consumer's demand for recreational trips. The demand curve shows how many trips the consumer takes per period at a particular price per trip. In this example, the consumer takes 10 trips per period at $3 per trip and no trips if the cost is $9 per trip. In this example, the consumer actually took 10 trips, thus expending $30. Total benefits are defined as the area under the demand curve to the left of 10 trips. However, the consumer only expended the area in the rectangle to receive these trips. Even though the consumer paid $3 per trip, she was willing to pay more than that for trips 1 through 9. Net benefits are then $30 (.5*($9-$3)*$10).

In this report, the type of goods whose benefits will be estimated fall into the broad category of quasi-public goods. A private good is one that is freely traded in the market place yet potential users can be excluded from using it. A candy bar is an example of a private good. A public good is one that any potential user cannot be excluded from using. The standard example of a pure public good is national defense. A quasi-public good is similar to a private good in that potential users can be excluded.

Figure 1
Relationship between net benefits and expenditures



Unlike a private good though, it is not freely traded in the market place. A National Wildlife Refuge is an example of quasi-public good. For this good, potential users, such as waterfowl hunters, can be excluded through the reservation process (such as a lottery for hunting permits). However, the price for this activity is not set in the marketplace. Instead, it is set through some bureaucratic process not necessarily reflecting the potential user's true WTP to use the site.

Although the nonmarket valuation techniques discussed here are generally used to estimate the benefits of public and quasi-public goods, survey methods similar to CVM have been used by private industry to aid in determining the price of goods not yet put in the marketplace.

Use and Nonuse Value

Public and quasi-public benefits can be divided into two general categories: use values and nonuse values. Use values consist of both consumptive uses, such as fishing, swimming, hunting, or irrigation, and nonconsumptive uses, such as bird watching. The distinction between consumptive and nonconsumptive values may sometimes be hazy. Nonuse values include option, existence, and bequest values. Option value is the value someone places on preserving the right to be able to use a good sometime in the future. Existence value is the value someone places on a good just for knowing that it exists, even if that person may never use or see the good. That this value actually exists is demonstrated by the fact that people pay wildlife organizations to help protect animal species such as African elephants or Humpback whales even though they will probably never see one (in the wild) in their lifetime. Bequest value is the value someone places on a good to protect a good for the use of friends, relatives, or future generations.

Of the types of benefits discussed above, TCM can only be used to estimate use values. TCM is based on observed recreational-site visitation data and therefore, unless some correlation can be observed between the good that is being assessed and the observed recreational site visitation, TCM is of no use. CVM, on the other had, can be used to estimate benefits for all the categories discussed above.

Theory and Empirical Issues for Travel Cost Models

The TCM method uses travel costs to a recreational site as a proxy for the price of the trip and the number of trips as quantity to statistically estimate a demand curve for a site. Once the demand curve is estimated, net willingness to pay can be calculated as the area under the demand curve above actual expenditures (fig. 1).[3] A traditional demand equation, with quantity demanded expressed as a function of the price of the good, cannot be used to model many recreational activities. Because recreation is a nonmarket good, the price for the good is not observed. However, if we assume that people respond to changes in travel cost in the same way they respond to changes in price, travel cost can be used as proxy for the price of the good.

Travel cost demand equations can be estimated using either the individual observation approach (such as direct surveys of recreationists) or zonal averages. In the zonal average case, one essentially estimates a demand curve based on the average distance and participation rates of zones. That is, since the quantity variable is trips per capita, it reflects the representative consumer. Data requirements for zonal TCM can be relatively modest. For example, the dependent variable can be derived from sign-up sheets at the recreational site (many recreational sites such as waterfowl hunting areas and hiking areas require sign-up sheets) as long as the recreationists are required to include their area of origin on the sheet. In spite of some loss in estimation efficiency over the individual

observation approach (Brown and Nawas, 1973), this section will concentrate on the zonal approach, due to its lower survey costs. However, to the extent that the true model diverges from the econometric specification, statistically more complex TCM models based on individual data do not necessarily outperform these relatively simple zonal models (Hellerstein, 1994). Fortunately, much of the analysis is the same under either approach. Since Ribaudo and Hellerstein (1992) provide the general theoretical background for recreational demand models, this section will concentrate on the mechanics of implementing TCM.

The zonal TCM demand equation specifies trips per capita from a given zone (such as a county) of origin to a particular site as the dependent variable. Observed visitation rates are assumed to reflect the desired level of consumption given the travel cost facing the recreationist (Dwyer, Kelly, and Bowes, 1977). The benefits of a recreational site/activity are reflected in the trips to a site and are generally determined by the cost of traveling to the site, various demographic characteristics, some qualitative aspects of the site, and the existence of substitute or alternative sites or activities. If the linear functional form is used (other functional forms are discussed in Appendix A), the basic per capita TCM demand equation estimated for site participation is:

$$[1] \qquad TRIPS_{ij}/POP_i = \beta_0 + \beta_1 TC_{ij} + \beta_2 DEMOG_i + \beta_3 QUALITY_j + \beta_4 SUBS_i + u_i,$$

where $TRIPS_{ij}$ is the number of recreational TRIPS from zone i to site j, POP_i is the population of zone of origin i, TC_{ij} is the round-trip average travel cost from the recreationist's zone of origin i to site j, $DEMOG_i$ are demographic variables such as average income, age, and years hunted of recreationists in zone i, $QUALITY_j$ can be hunter success, dock availability, or other site characteristics that determine the desirability of site j, $SUBS_i$ is price or availability of substitute recreational sites for origin i, and u_i is a white noise term. Travel time is sometimes included as an explanatory variable but is frequently highly correlated with travel cost.

Given the regression estimate of equation (1), the total net benefits (technically known as consumer surplus) for site j for residents from zone i is the area under the demand curve above current costs per trip, which would be the area in the triangle in figure 1 times the population of zone i. Total net benefits for the site would be the sum across each origin i's net benefits for site j.

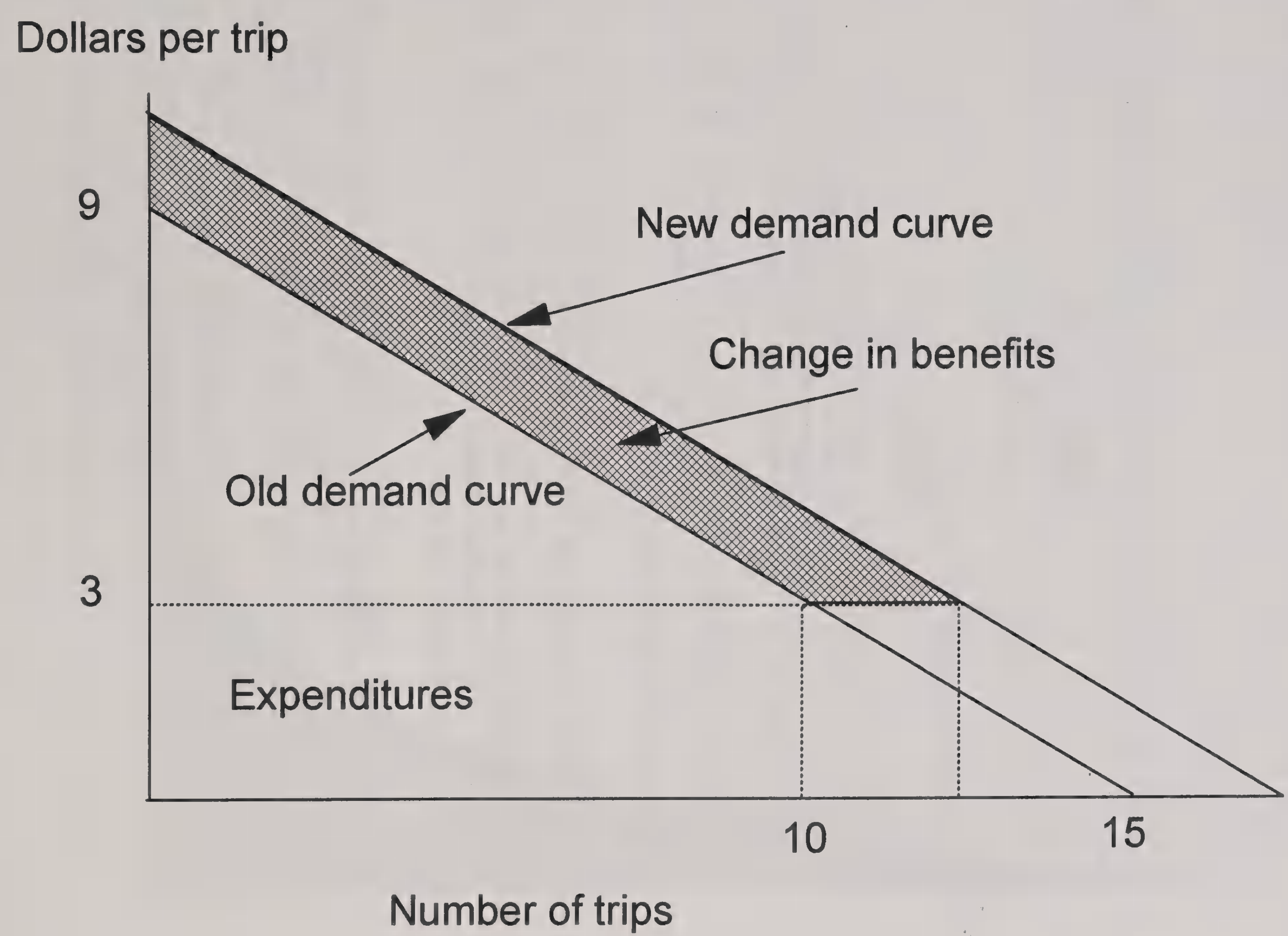
A frequent goal of a TCM study is to calculate the change in net benefits associated with a change in a qualitative or quantitative attribute of the site, such as acreage at the site open to recreationists.[4] A site improvement such as this would shift the demand curve out to the right. The increase in net benefits is denoted by the cross-hatched trapezoid in figure 2 (see appendix A for further detail). Two of the case studies presented in this report demonstrate how agricultural activities can shift the demand curve, and thus, change total net benefits.[5]

Requirements to Interpret Distance as Price

The reasonableness of interpreting the travel distance as the price paid to visit the site depends on that site not being part of a multiple destination trip. For travel distance and travel cost to be considered the price paid to visit the site, such travel costs must be incurred exclusively to gain access to the recreation site. Of course, to minimize the bias of the TCM estimates, the recreationist needs to implicitly view the travel distance itself as a cost, with the longer and more time consuming the travel, the higher the implicit cost. If the road time itself is viewed as enjoyable and as part of the recreational objective, as has been observed in some cases (for example, someone may choose the longer route to get to the site if it is more scenic than alternative routes), then it can be problematic to use travel distance as a proxy for the price of the trip.

Figure 2

Increase in benefits associated with an increase in site quality



Benefit Estimation

Appendix B contains technical details on the estimation of the coefficients ($\beta_1, \beta_2, ... \beta_k$, where k is the number of variables in the equation) for the demand function presented in equation (1). Once the demand coefficients are estimated, net benefits can be calculated utilizing the second stage, or site demand curve approach.[6] This site demand curve relates total site visitation to increases in distance (or travel costs) over and above the existing distance (or cost). Starting with current trips and round trip distance $RTDIST_{ij}$, additional round trip distance is added to $RTDIST_{ij}$ (for example, 10-mile increments) in the demand equation and the new level of estimated $TRIPS_{ij}$ calculated for each origin to each destination.[7] Total estimated trips at each successive distance is the sum across observations of total estimated trips for each observation. The area under the generated site demand curve is net WTP (in miles).

Figure 3 provides an example of an estimated second stage demand curve. The demand curve shows that there are 1,500 trips (from all zones of origin) to the recreation site in the base state, such as in the case with zero additional round trip miles. On the other hand, if additional round trip miles per trip from each zone is raised by 100 miles, total trips will fall to a little over 500. The cross-hatched area under the curve is total net benefits, measured in miles. This area, when multiplied by the travel cost per mile (see below), is the net benefits associated with the site.

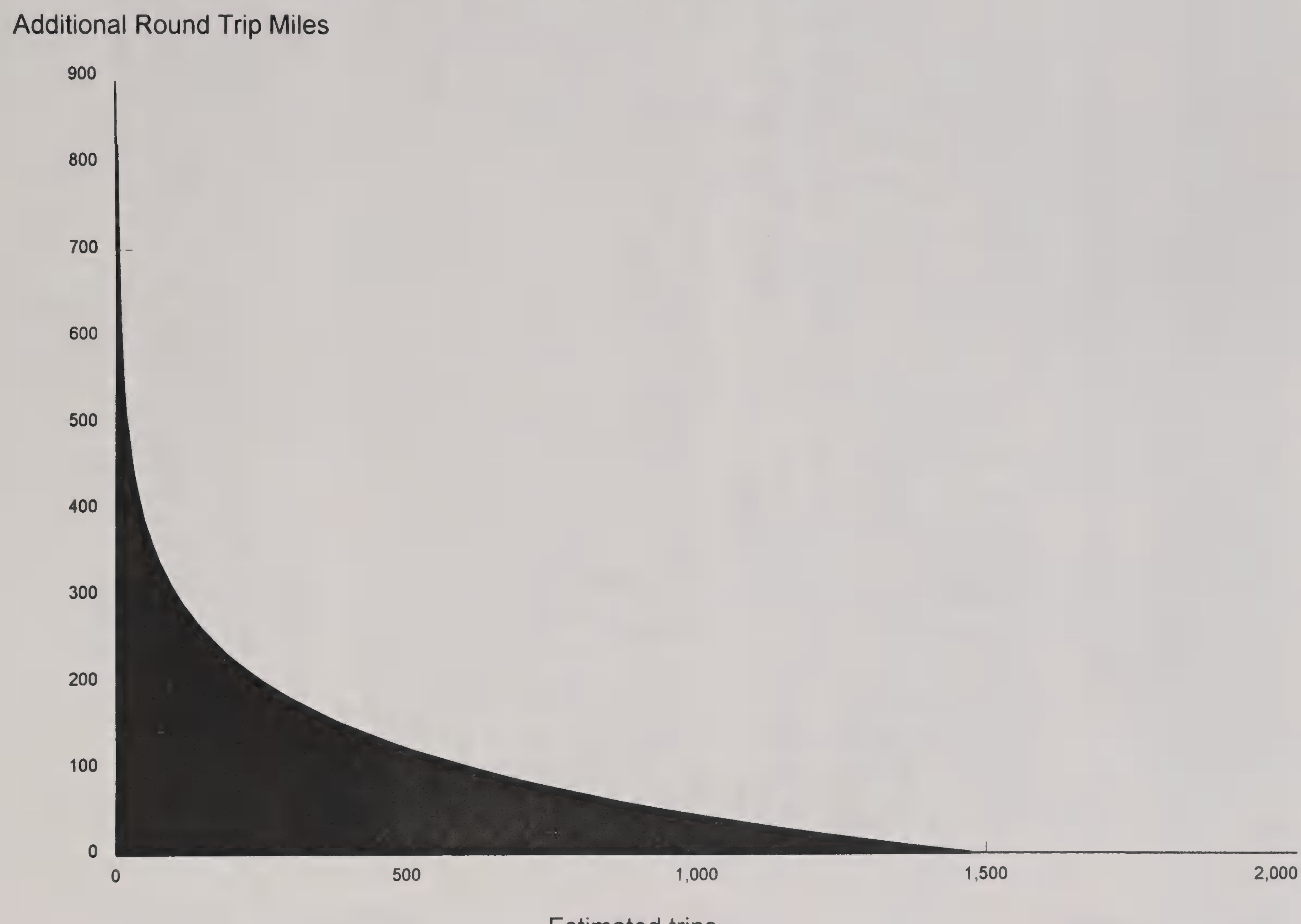
Conversion of Miles to Dollars

The approach to converting the added WTP in miles into dollars follows U.S. Water Resource Council procedures (1979, 1983) of using variable automobile costs obtained from the U.S. Department of Transportation or other sources. For the case studies, the standard vehicle transportation cost per mile represents the variable cost of operating an intermediate-sized vehicle. This figure, which was \$.145 per mile for fuel and service station costs in 1988, was obtained from the 1989 issue of the Hertz Corporation survey of vehicle operating costs. With more than one recreationist per vehicle and assuming each recreationist in the vehicle will pay an equal share of the vehicle operating costs, per-mile costs for individuals will be the per-vehicle-mile operating costs divided by the average number of recreationists (passengers) per vehicle.

The opportunity cost of travel time reflects the deterrent effect that longer drives have on visiting more distant sites, independent of the vehicle operation costs. For example, many higher income people could afford an extra \$8.00 of gasoline incurred through driving an additional two hours, but many could not afford the additional time cost in terms of other activities forgone. Empirical evidence supports the contention that time allocated to transportation is viewed by the recreationist as costly (Cesario, 1976; McConnell and Strand, 1981).

The hourly wage is used as a proxy for the opportunity cost of time. This is in part due to work by Cesario (1976), which showed that the opportunity cost of time in commuting studies fell somewhere between one-fourth and one-half the wage rate. Since no information on individuals is available for the data sets used in the case studies presented here, the wage rate will be used as a proxy for opportunity cost of time in all other activities and it is used even if the recreationist would not have been working. The U.S. Water Resources Council Principles and Guidelines (1979 and 1983) suggest that the opportunity cost of time be calculated as one-half of the average wage rate. One should recognize that the issue of what fraction of the wage rate to use is not settled. For instance, Smith and others (1983) argues for using 100 percent of the wage rate. Generally, one-third to one-half the wage rate is used. The average wage rate can be calculated as yearly recreationist income (using census data if necessary) divided by 2,000 total work hours per recreationist. Next, this new dollar per hour figure is divided

Figure 3
Second stage demand curve for a recreational site



by the average travel time (round trip) between the between the origins and destinations for the study site. The resulting figure, when multiplied by some fraction of the wage rate, is the opportunity cost per mile. Total variable cost per mile per recreationist is this opportunity cost of time plus the recreationist's share of the vehicle operation costs. It is also possible to determine the value of time empirically (Shaw, 1992; McConnell, 1992). However, these models require relatively detailed surveys of the recreationists.

Theory and Empirical Issues for the Contingent Valuation Method

CVM uses surveys in which people are asked how much they are willing to pay for a change in the level or condition of some nonmarketed good (for example, a good that does not have a market price). Before asking this valuation question, the usual survey gives a description of the good and the level of change in the good. The basic notion underlying CVM is that a realistic but hypothetical market for "buying" (or "selling") use and/or preservation of a nonmarketed good can be described to an individual. The individual is then told to use this hypothetical market to express a valuation of the good. Key features of the hypothetical market include: (1) description of the resource being valued; (2) means of payment (often called the payment vehicle), such as an increase in taxes or in a utility bill; and (3) the value elicitation procedure. The payment vehicle should be realistic and emotionally neutral for the respondent. To improve realism, the payment vehicle should be appropriate for the good and the constructed market. The baseline level of provision of the good as well as the change in the provision should be clearly stated. Plus, the researcher should take care to ensure that the respondents are perceiving the correct good.

CVM has been shown to be reliable, especially for estimating user values. For example, Loomis (1989) found that CVM is reliable in retesting, such as when survey respondents were asked the same CVM questions approximately 9 months after the first survey, the new WTP estimates were found to be statistically the same as the old estimates. Adamovicz and Graham-Tomasi (1991) found that CVM is generally consistent with the axioms of revealed choice. At least for familiar goods and services, such as drinking water, CVM typically has been shown to compare very favorably with other nonmarket resource valuation techniques, such as travel cost, hedonic, simulated market results, and the outcome of actual referenda (Mitchell and Carson, 1989; Cummings, Brookshire, and Shulze, 1986). However, CVM has been somewhat controversial for estimating nonuse values. Largely due to complaints by Exxon and the American Petroleum Institute regarding the high economic damage estimates estimated with CVM for the Exxon Valdez oil spill, the National Oceanic and Atmospheric Administration (NOAA, U.S. Department of Commerce) formed a Blue Ribbon panel (co-chaired by Kenneth Arrow and Richard Solow) to assess the validity of using CVM for natural resource damage assessment. The panel has approved of the applicability of CVM for this type of assessment as long as its guidelines are adhered to (U.S. Department of Commerce, 1993).

Guidelines for Implementing CVM

Potential biases and sources of bias sometimes associated with CVM-based benefits estimates include (U.S. Department of Commerce, 1993): 1) overstatement of "real" WTP; 2) apparent inconsistency with the assumptions of rational choice, for example people should be willing to pay more for more of a normal good; 3) implausibly large estimates in view of the many programs for which individuals might be asked to contribute; 4) inadequacy of the information provided to the respondent on the good to be valued; and 5) CV response may actually express the respondent's feeling on the subject (warm glow) rather than actual WTP.

To reduce the effects of these potential biases on the benefits estimates, careful attention should be paid to the survey design. Mitchell and Carson (1989) and the NOAA report (U.S. Department of Commerce, 1993) discuss specific guidelines for performing CVM surveys. Specific guidelines addressed by the NOAA panel (ibid) include: 1) use probability sampling techniques (Cooper, 1993a) to reduce variance and bias of the estimates; 2) take actions to minimize the number of nonrespondents; 3) use personal (face-to-face or telephone) interviews instead of mailed-in surveys; and 4) carefully pretest the CV questionnaire. Of the guidelines set out by the NOAA panel, 3) is probably the most controversial, as mailed surveys can provide an inexpensive alternative to in-person questioning for surveys that are too complex to perform over the telephone.

The rest of this section largely pertains to referendum, or dichotomous choice, CVM approaches. The dichotomous aspect is that the respondent is prompted to provide a yes or no response (or vote, hence the term referendum) to a dollar bid amount contained in the valuation question. The bid amount is varied across the respondents.[8] While this is the basic and most common referendum approach, variations on this approach do exist.[9] This method, in particular, is asserted to reveal accurate statements of value since the format provides reasonable incentives for value formulation and reliable value statement (Hoehn and Randall, 1987; U.S. Department of Commerce, 1993). In fact, in the proposed NOAA guidelines for conducting natural resource damage assessment using CVM, the panel suggested that all CV studies should use the referendum format.

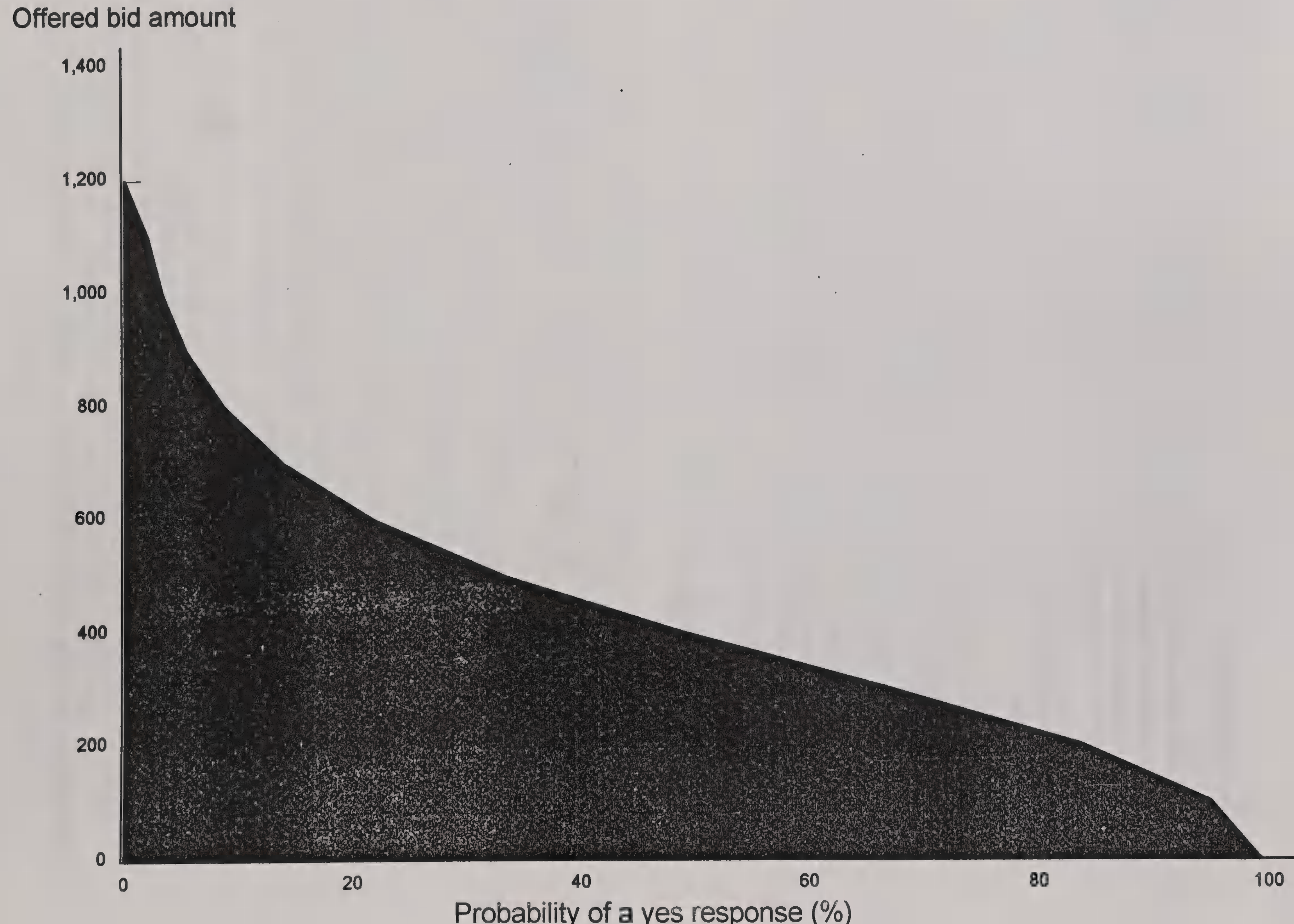
Derivation of the WTP Measure for Dichotomous Choice CVM

How is it possible to derive a net benefit estimate from a set of yes or no responses to a set of bid values? One concern is: "Well yes, the respondent agreed to pay the $50 bid you offered, but probably would have paid $125 if you had asked. How are you going to estimate maximum WTP when all you know is the dollar amount he said 'yes' to?" The answer is that the researcher can statistically infer maximum WTP from these responses to the different bids by using a qualitative dependent variable regression (for example, logit, probit, or weibit) on the data. For figure 4, the estimated coefficients from a qualitative dependent variable regression of the yes/no responses on the bid variable are inserted into a cumulative density function (CDF), which in this case is a Weibull distribution (Cooper and Loomis, 1993).[10] The CDF is the probability that WTP is less than or equal to the $bid, or Prob(WTP <= $bid). The curve in the graph relates 1 - Prob(WTP <= $bid), which equals "Yes, I would pay," to the offered bid amounts. In the figure, the curve shows that a predicted 100 percent of the respondents would be willing to pay $0 and 0 percent would be willing to pay $1,200. The cross-hatched area under the curve is the net benefit. As the reader can verify, this area is approximately $435. Appendix C provides a utility theoretic basis, known as the utility difference approach, for the derivation of the referendum CVM benefit measure.

Another issue in dichotomous choice CVM is sample design, such as how to choose the bid values to put in the WTP questions. Cooper (1993a) presents a procedure that chooses the bid values ($\$bid_1, \$bid_2, ..., \$bid_m$) and the number of surveys that receive each bid ($n_1, n_2, ..., n_m$), such that the mean square error of E(WTP) is minimized, where the true mean is assumed to be that derived from a pre-test survey. However, Cooper and Loomis (1993) show that for large sample sizes (approximately 1,000 observations), the WTP estimate is not particularly sensitive to sample design, especially if the distribution used in the likelihood function is close to the true underlying distribution of WTP.

Figure 4

Response curve for a WTP question



Confidence Interval Estimation for TCM and CVM

While the benefit estimates generated in figure 3 for TCM or in figure 4 for CVM provide us with a useful starting point for policy analysis, the informational value of these estimates would be much higher if we could have some measure of their precision. Without confidence intervals around a set of welfare estimates for different levels of a public good, we cannot judge whether changes in the levels of these goods result in statistically significant changes in welfare. It is of little value to say that the net WTP point estimate for an increase in site quality is twice as high as that in the base state if this difference is only due to some random elements in demand estimation and not due to a true systematic difference. Because net benefits are a nonlinear function of the coefficients, a significant coefficient on site quality will not necessarily mean that the change in net benefits is statistically significant. Since the benefit estimates are nonlinear functions of several random variables, simple t-statistics cannot be used to construct confidence intervals. More complex approaches are required. Cooper (1993b) describes several methods and provides the computer programs required to estimate the confidence intervals.

Now we turn from the theoretical descriptions of the TCM and the CVM to several case studies of applications of these methods that have agricultural implications. The TCM case studies are: 1) an examination of the effects of agricultural activities on waterfowl hunting benefits in the Kesterson National Wildlife Refuge; and 2) a comparison of the value of water in recreational use versus agricultural use in California's San Joaquin Valley. Finally, the CVM case study addresses the minimum level of incentive payments needed to encourage farmers to use environmentally sound management practices.

Case Studies of Application of CVM and TCM to Agricultural Issues

Effects of Agricultural Activities on Waterfowl Hunting Benefits in the Kesterson National Wildlife Refuge

In this case study, we estimate the economic impact of agricultural activities on wildlife. Specifically, this case study is a TCM application assessing the lost hunting benefits in the Kesterson National Wildlife Refuge in California's San Joaquin Valley due to selenium-contaminated agricultural runoff. Using the number of hunting permit forms as the quantity variable, zonal TCM demand curves were estimated and net WTP was calculated for waterfowl hunting in California's San Joaquin Valley refuges for the 1987-88 hunting season. In the October 1987 through January 1988 hunting season, 27,603 hunters went to these seven refuges.

For this study, applications (hunting permits) data were used as the quantity variable as trip data were not available. However, this substitution does have the positive characteristic that the number of hunting applications for site j filed by hunters from origin i is the unconstrained demand for the site. Applications reflect the consumption that waterfowl hunters desire at current permit and travel prices.

The estimated model, which includes six other San Joaquin Valley refuges, is:[11]

[2]
$$\ln(APPLICATIONS_{ij}/POP_i) = \underset{(-7.77)}{-24.277} - \underset{(-15.25)}{1.406}[\ln(TWOWYDIST_{ij})]$$
{t-statistics}

$$+\underset{(2.53)}{0.235}[\ln(HVST_j)]+\underset{(2.33)}{0.733}[\ln(AVINCOME_i)]+\underset{(9.96)}{1.301}[\ln(WATER_j)],$$

where:
TWOWAYDIST=two-way trip distance from the hunter's resident county i to refuge j. This variable is the price (in terms of distance travelled) of visiting the refuge;
HVST=average of the monthly total waterfowl harvest for all hunters in the previous season, such as in the 1986 season, in refuge j;
AVINCOME=average income in county i;
WATER=total water supplied (acre-feet) to refuge j's wetlands during the hunting season. (This variable is a proxy for the amount of waterfowl habitat at a refuge);
R-squared = 0.607; F-Statistic = 102.23; and observations = 270.

The R-squared is quite high for a cross-sectional TCM regression. In addition, all the coefficients are of the expected sign, and all are significant at the 5-percent level or higher. Note that inclusion of all six sites in the regression allows us to include the $HVST_j$ and $WATER_j$ variables, which only vary across sites in this cross sectional model.

Given equation (2), net benefits are estimated using the second-stage approach discussed earlier. Table 1 presents the average net benefits per hunter day and the total net benefits for the San Joaquin National Wildlife Refuges and Wildlife Areas. Net benefits per hunter-day is equivalent to net benefits per application as an application is only valid for one day. Since the demand equation (2) underestimates applications, the benefit estimates err on the conservative side. However, because of the double-log formulation, this underprediction does not affect net benefits per trip. Column 2 is actual hunter days per year. The third column is the product of columns one and two.

Table 1—Net benefits per hunterday and total consumer for the 1987-88 season, selected San Joaquin Valley wildlife areas, 1987-88 season.

Refuge	Average net benefits per hunter day	Hunter days per year	Total net benefits	Total hunters
	Dollars	*Number*	*Dollars*	*Number*
Kesterson NWR	37.19	3,900	145,000	1,803
San Luis NWR	51.11	9,000	460,000	3,418
Merced NWR	43.46	1,700	73,880	710
Volta WA	60.01	3,500	210,000	4,067
Los Banos WA	62.98	3,500	220,400	3,354
Mendota WA	63.74	31,723	2,022,000	12,055
Kern NWR	69.36	1,300	90,170	2,196
Average	55.41	54,600	3,222,000	27,603

NWR = National wildlife refuge.
WA = Wildlife area.

Because the estimated model includes harvest, it can be used to estimate how waterfowl hunting benefits alter with changes in harvest induced by contamination of the refuge water supply.

In the San Joaquin Valley refuges, the primary harm to wildlife resulting from agricultural drainage is due to the high selenium concentration in much of the drainage water. Although selenium is a necessary nutrient for life, high concentrations can cause both deformities and death. Selenium is particularly harmful to waterfowl embryos. The majority of refuges listed in table 1 receive little agricultural drainage, and, correspondingly, have nonlethal levels of selenium. However, the concentration of selenium at Kesterson, which was a major receptor of agricultural drainage, was especially high and lethal to a large percentage of the waterfowl population that had bred there.

Ohlendorf (1989) estimated the frequency of embryotoxicity (dead or deformed embryos or chicks) attributable to selenium in nesting aquatic birds at the Kesterson refuge during 1983-85. In 1983 (the only year for which coot data are available), 64.4 percent of coot nests had one or more dead or deformed embryos or chicks. For 1983-85, an average of 34.9 percent of duck nests had one or more dead or deformed embryos or chicks.

The reduction in these death and deformity figures is used to determine the increase in waterfowl hunting benefits at Kesterson associated with a reduction in selenium concentrations to nonlethal levels. To do this, the 1986 waterfowl harvest data used to estimate equation (2) were separated into its duck, geese, and coot components, which were 94.4, 2.0, and 3.6 percent of total 1986 harvest, respectively, for the San Joaquin Valley refuges (California Department of Fish and Game, 1986 Waterfowl Hunting Season Report). The percent of harvested ducks and coots bred in the San Joaquin Valley is estimated using Department of Fish and Game estimated 1989 breeding population data for the San Joaquin Valley refuges.[12] The figures suggest that 11.5 percent of the total winter duck population and 3.9 percent of the total winter coot population are bred there. For a lack of better information, it is reasonable to assume that of the ducks and coots harvested in Kesterson, 11.5 percent and 3.9 percent, respectively, were bred there.

Using the embyrotoxicity figures listed above, the increase in the number of harvested ducks and coots bred at Kesterson due to a decrease in the selenium levels to nonlethal concentrations is calculated. Without factoring the possibility of compensatory mortality due to a lack of information on its magnitude, it is assumed that 64.4 percent of dead or deformed coot embryos or chicks and 34.9 percent of dead or deformed duck embryos or chicks would have survived at nonlethal selenium concentrations. For want of more detailed embryo or chick mortality data, the dead or deformity percentages, which are the percentages of all nests with one or more dead or deformed embryos or chicks, are assumed to be the total death or deformity percentages for a clutch of eggs. This plus the preceding assumption may lead to a liberal estimate of the increase in native waterfowl population due to a decrease to nonlethal levels of the selenium concentration. On the other hand, no adjustment is made for the possible decrease in reproductive ability of waterfowl that inhabit the refuge in winter but breed somewhere else, as no data exist on this topic.

Using the figures cited above, of the 509 waterfowl harvested in Kesterson in 1986, 51 ducks and 1 coot were estimated to be bred there. With selenium reduced to a nonlethal concentration, 538 waterfowl (a 5.7-percent increase) would have been harvested there. Substituting this harvest figure into equation (2), yields a 1.4-percent increase in Kesterson hunting applications. This percentage increase translates into an increase of 55 hunter days in the sample expansion of Kesterson hunter visitation figures from table 1. With this small increase, the potentially negative impact of crowding from increased visitation on applications should not be of major concern. With this increase in hunter visitation, the total net benefits increase by $2,030. Assuming a 100-year horizon for this increased

surplus and an 8-percent discount rate used by Federal water resources agencies, the present value of this increase in net benefits is $25,400.

An increase in the total economic benefits of bird viewing at Kesterson resulting from a decrease in selenium concentration to nonlethal levels should be added to this figure. However, a lack of Kesterson bird viewing data makes this addition difficult at this time. But, the values estimated do give a lower bound to the net benefits losses at the site.

Implications

By linking reductions in contamination to increases in waterfowl breeding populations at Kesterson National Wildlife Refuge, an estimate of added benefits to waterfowl hunters can be computed for reductions in contamination. Even though some values for Kesterson wildlife could not be quantified, this case study demonstrated how recreational use of wildlife could be quantified and linked to agricultural contamination issues. More precise estimates of the economic effects await better biological data for onsite and offsite contamination effects on migratory birds.

Estimation of the Marginal Value of an Acre-Foot of Water in Recreation Versus Agriculture

This case study makes a comparison of the marginal value of an acre-foot of water in recreational use versus agricultural use, thus aiding the policymaker in the best use of additional units of the resource. The specific application is water deliveries to San Joaquin Valley National Wildlife Refuges.

Data Sources

This case study uses a more recent data set (Cooper, 1990) than the one used in the previous case study. This data set consists of the whole population of hunters to the six San Joaquin Valley National Wildlife Refuges for the 1989-90 hunting season. Waterfowl hunting trip data for San Joaquin Valley refuges were obtained from onsite sign-up sheets hunters are required to sign before they enter the hunting area. Hunters are required to list their license number and home zip code. The sheets include both reservation holders and those hunters that show up for the "sweat line" (hunters without reservations who arrive at the refuge and are granted the remaining available slots in the hunting area). Hunters are aggregated by county of origin. To avoid truncation bias, all counties in California where no hunters originated from were retained in the survey. The availability of this data, which was collected for administrative purposes, shows how it is possible to do TCM studies without funding an original survey.

The qualitative variable of key interest in this case study is the level of water deliveries (H20DEL, measured in acre-feet). Increasing water deliveries to a site affects recreational demand by increasing the waterfowl population, and hence harvesting opportunities, at the site, and also by increasing the aesthetic quality of the refuge. Unlike many possible site characteristics that are not realistically under societal control, such as the amount of snow cover, water delivery to the wildlife refuges is largely controllable. Hence, an analysis of the effects of changing this variable is policy relevant.

The distance figures from the counties to the refuges were determined using a California Department of Transportation (CALTRANS) computer program. CALTRANS also supplied the household income and county population figures. Because many of the Merced County refuges are centered within a

close proximity of each other, that county was divided into smaller regions. This segmentation increases the precision of the distance variable.

Statistical Results

Two regression techniques—ordinary least squares (OLS) and the Poisson count model— were used on the data to estimate the TCM demand equation coefficients. For reasons discussed in appendix D, the Poisson model is preferred over the OLS model. However, because OLS is the traditional regression technique, OLS coefficient estimates are still useful for comparative purposes. The regression results for these two models are found in table 2. In table 2, all coefficients are of the expected sign and are statistically significant.[13] All the OLS coefficients were larger than the Poisson coefficients, with the greatest difference being that for INCOME and the smallest that for H20DEL. Appendix D contains more detailed results.

Model Application

An application of the above model that could be valuable in policy-making decisions is to calculate the marginal value of an acre-foot of water in recreational uses. Much pressure has been put on the Bureau of Reclamation to allocate more water to National Wildlife Refuges. The economically optimal water distribution plan would be one that allocates water to each use to the point where the marginal value of the water in each use is equal.

Table 3 presents the marginal values calculated using both the OLS and the Poisson results from table 2. The marginal values are defined as the changes in total net benefits to waterfowl hunters of an additional acre-foot (over the current delivery levels) of water delivered to each refuge. This would be equivalent to the shaded area in figure 2, where the new demand curve is one that incorporates a one acre-foot increase in water deliveries. The 90-percent confidence intervals were constructed using the Krinsky and Robb approach (Cooper, 1994) with 1,000 draws. For the Poisson and OLS models, the average of the draws ranged from $0.93 and $0.64, respectively, for Merced, the least visited refuge. For Mendota, the refuge with the greatest visitation, the Poisson and OLS results were $20.40 and $14.05, respectively. These marginal values form a lower bound on the marginal values to recreation as they only include waterfowl hunting. For comparative purposes, table 4 presents the uncalibrated results (the demand equation is not adjusted such that base estimated trips per site are equal to actual trips per site). Because the demand curve passes through average price and quantity in the uncalibrated equation, the difference across sites in the WTP point estimates is lower for the uncalibrated results than for calibrated results. Since waterfowl hunting makes up only 14-19 percent of the total recreational use of refuges, depending on the relative value of water in waterfowl hunting versus fishing, the marginal recreational values of water in table 3 could be several times higher (Calliga, 1982; Creel and Loomis, 1991). However, the values in table 3 are important because they provide the lower bounds to the marginal recreational value of water.

Several researchers have estimated the marginal value of an acre-foot of water to California agriculture (see Gibbons, 1986, for a literature review). For this paper, the Economic Research Service's U.S. Agricultural Resource Model (Konyar and McCormick, 1990) was run specifically for California. This model is a partial equilibrium, comparative statics programming model.[14] Running the model expressly for California yielded a shadow price (using 1987 crop prices) of $13.37 for an acre-foot of irrigation water. The true shadow price, or marginal value, for the San Joaquin Valley would differ from this value depending on the extent to which the water bound for the San Joaquin Valley can be transported to other parts of the State and on how different the crop mix for the San Joaquin Valley is from the crop mix representative of the State. This $13.37 value is greater than the marginal recreational value for all sites except Mendota. Hence, additional water for waterfowl hunting at Mendota is competitive with agricultural use. When the presently unquantified benefits to nonconsumptive wildlife use are added in, the benefits of increases in water deliveries to some of the

Table 2—OLS and Poisson coefficient estimates for the TCM demand equation

Variable	Log-Linear OLS	PML Poisson
Constant	-16.2610	-8.8154
	(-10.8342)[a]	(-59.48)
RTDIST	-0.01496	-0.00887123
	(-11.28)	(-28.39)
INC	0.000109	4.2163E-06
	(3.2789)	(1.573)
PSBAG	36.1707	10.51211
	(4.0791)	(3.94)
H20DEL	0.000145	0.0001257
	(2.58)	(18.04)
α [b]		26437
η^2 [c]	0.268	0.516

The variables are:

RTDIST is round trip travel distance from county i to refuge j.
H20DEL is water deliveries to refuge j.
INCOME is average income in county i.
PSBAG is the price, in terms of round trip distance, of the most popular alternative refuge to refuge j for residents of origin i divided by the bag at that site.

Total observations = 396.

[a] Coefficient divided by its standard error in parentheses.

[b] The standard error for α is not available with PML estimation.

[c] $\eta^2 = 1$ - RSS/TSS, where RSS is explained sum of squares and TSS is total sum of squares. For OLS (with a constant term), η^2 equals ESS/TSS, though this is not necessarily the case for nonlinear models (Peterson and Stynes, 1986).

Table 3—Marginal value of an additional acre-foot of water in waterfowl hunting (change in total net benefits with a one acre-foot increase in water deliveries)*

	PML Poisson regression			OLS regression		
Refuge	Lower	Upper	Average	Lower	Upper	Average
			Dollars			
Kesterson	2.99	3.71	3.34	0.91	3.84	$2.30
Los Banos	7.70	9.57	8.62	2.35	9.92	5.94
Mendota	18.24	22.66	20.40	5.55	23.48	14.05
San Luis	5.75	7.15	6.43	1.75	7.40	4.43
Volta	6.88	8.55	7.70	2.10	8.86	5.30
Merced	0.83	1.03	0.93	0.25	1.07	0.64

*Confidence intervals based on 1,000 repetitions.

Table 4—Marginal value of an additional acre-foot of water in waterfowl hunting (change in total net benefits with a one acre-foot increase in water deliveries) using uncalibrated PML Poisson regression

	Marginal value		
Refuge	Lower	Upper	Average
		Dollars	
Kesterson	1.95	2.24	2.09
Los Banos	9.22	12.66	10.87
Mendota	12.80	20.24	15.61
San Luis	6.49	8.18	7.32
Volta	4.46	5.24	4.85
Merced	6.46	8.28	7.35

Note: Unlike in table 3, for the calculation of the net benefits, the demand curve is not shifted such that it passes through actual price and quantity.

other refuges in the San Joaquin Valley may be greater than or equal to the forgone marginal value of agricultural water in the San Joaquin Valley, with the Merced National Wildlife Refuge being a possible exception in table 3 or Kesterson in table 4.

At a macro level, economic theory suggests that water should be allocated between agriculture and the national wildlife refuges such that the marginal value of water is equal between the two uses. At a less macro level, if the goal of the Bureau of Reclamation would be to allocate water to the sites to maximize the total recreational benefits provided by the national wildlife refuges, it should reallocate the water deliveries between the refuges such that the marginal recreational values of an acre-foot of water are equated across the refuges. This is not currently the case for majority of the sites, based on the Poisson confidence intervals. For example, the marginal value estimates in table 3 suggest that too much water is being delivered to the Merced and Kesterson refuges and too little to Mendota.

Implications

For one of the six refuges, the marginal value of water in waterfowl hunting was at least as great as the marginal value of water in agriculture. In order to make more complete comparisons of the benefits of water use, further research is needed to quantify the marginal value of water to other popular recreational uses of refuges such as bird watching and fishing.

Application of CVM to Determine Incentive Payments to Encourage Use of Environmentally Sound Management Practices

In response to increasing public concern over the contribution of agricultural pollutants to the degradation of surface and ground water supplies, the 1990 Food, Agriculture, Conservation and Trade Act (FACTA) authorized the USDA to initiate the Water Quality Incentive Projects (WQIP). WQIP is administered by the Consolidated Farm Services Agency (CFSA—formerly the Agricultural Stabilization and Conservation Service) through the Agricultural Conservation Program (ACP). Its goal is to mitigate the negative impacts of agricultural activities on ground and surface water supplies through the use of stewardship payments and technical assistance to operators who agree to implement approved practices. With these incentives, farmers are encouraged to experiment with more environmentally benign production practices than they otherwise would adopt. For most practices, the program offers a flat per acre rate (usually around $10/acre) with a maximum of $3,500 per contract per year. In 1992 and 1993 the funding levels for WQIP were $6.75 million and $15 million respectively. Currently, farmers in only a small number of watersheds are eligible to enter the program. However, the issue has been raised of making this type of incentive payment program more widely available (Sinner, 1990).

The WQIP incentive payments are not determined through market interaction. Since the current program offers only a flat rate per acre for each practice, a supply curve cannot be identified that measures the numbers of acres switched over to the preferred practice as a function of incentive payment level. Our goal is to model the probabilities of participation as a function of a range of incentive payment offers. This response function would be useful in studies comparing the benefits and costs of the various preferred management practices. In addition, since the farmer is free (within limits) to determine how many acres to put into the program at the offered incentive payment level, our second goal is to determine how many acres the farmer will devote to the new practice, given that the farmer will adopt the practice.

The USDA believes that the preferred practices we will examine in this paper are profitable for the farmer. Yet, even though their implementation should theoretically boost profitability, not all farmers who could adopt these practices have done so. For farmers in the data set used here, current adoption of the discussed practices ranges from 7 percent to 73 percent. Some of the nonadoptors may not be able to adopt the practice for some physical reason.[15] However, most of the nonadoptors can use the

practices but have not done so for reasons not directly pertaining to profitability. One reason may be that the farmer is risk averse: even if the alternative practice might appear profitable on paper, the farmer may be unwilling to adopt the practice unless the farmer sees neighboring farmers adopting it. Another reason for not adopting the practice might be that the farmer either has no, or insufficient, information about the alternative practice. Hence, an empirical comparison of profits or costs under the old and the new practices will not provide enough information to determine the necessary incentive payment to encourage adoption. To avoid these problems associated with estimating minimum WTA to change practices as the difference in cost or profit between the two states, one can use a direct revelation technique for assessing WTA.

Theoretical Basis for Estimating Willingness to Accept in the Case of No Market Transactions

With dichotomous choice CVM, instead of trying to identify the farmer's profit function (which, at any rate, would not include any profit-independent reasons to accept the program), we simply need to determine whether or not the farmer's minimum WTA is greater than or equal to the offered payment incentive. [16] The farmer's decision process can be modelled using the same random utility model approach discussed in appendix C. Appendix E discusses a modified version of this model.

For an assessment of the incentive program, the mean, or median value is of secondary importance to estimating the probabilities of participation in the program for a schedule of incentive payments. These can simply be obtained through $P_i = F_\varepsilon(\Delta_i)$. From a cost-effectiveness standpoint, the optimal rates of acceptance may not be the same for each practice.[17]

Data Description

The Area Studies project is a data collection and modelling effort of the Economic Research Service (ERS), the U.S. Geological Survey (USGS) and the National Agricultural Statistics Service (NASS). Data on cropping and tillage practices and input management were obtained from a comprehensive field and farm level survey of about 1,000 farmers in each of four critical watershed regions: the Eastern Iowa and Illinois Basin areas, the Albemarle-Pamlico Drainage Area covering Virginia and North Carolina, the Georgia-Florida Coastal Plain, and the Upper Snake River Basin Area. These study areas were selected from within the set of USGS National Water Quality Assessment (NAWQA) sites, and sample sites were chosen to correspond to NRCS' National Resource Inventory (NRI) so that information on the physical characteristics corresponding to farming activities would be available. For example, slope and erosion potential of the soil would seem to be factors that may influence the decision to adopt conservation tillage.

Information about the extent of the farmers' current use of the preferred practices as well as their willingness to adopt these practices if they do not currently use the practice were provided by a supplemental questionnaire. Respondents to the comprehensive questionnaire were asked to complete and mail in this additional section. For the final analysis, 1,261 observations were available.

The practices analyzed here, a short description of each, and the current incentive payment levels are:

Conservation tillage (CONTIL) — Tillage system in which at least 30 percent of the soil surface is covered by plant residue after planting to reduce soil erosion by water; or where soil erosion by wind is the primary concern, at least 1,000 pounds per acre of flat small grain residue-equivalent are on the surface during the critical erosion period. Incentive payment cannot exceed $12 per acre.

Legume crediting (LEGSR) — Involves estimating the amount of nitrogen available for crops from previous legumes (such as alfalfa, clover, and cover crops) and reducing the application rate of commercial fertilizers accordingly. Incentive payment not to exceed $10 per acre for row crops.

Manure testing (MANTST) — Involves estimating the amount of nutrients available for crops from applying livestock or poultry manure and reducing the application rate of commercial fertilizer accordingly. Incentive payment cannot exceed $10 per acre for row crops.

Split applications of nitrogen (SPHN) — Involves applying one-half or less of required amount of nitrogen for crop production at or before planting, with the remainder applied after emergence, in order to supply nutrients more evenly and at times when the crop can most efficiently use them. Incentive payment cannot exceed $10 per acre for row crops.

Soil moisture testing (SMTST) — Involves use of tensiometers or water table monitoring wells to estimate the amount of water available from subsurface sources. Incentive payment cannot exceed $10 per acre.

All of these practices are currently being supported by WQIP. For the willingness to adopt question for all of the practices except conservation tillage the bids offered are ($2, $4, $7, $10, $15, and $20). For conservation tillage the bids are ($4, $6, $9, $12, $18, and $24). The bid ranges were chosen to cover what we perceived to be the likely range of WTA. The bids were randomly assigned with equal probability to the surveys.[18] The specific referendum CVM question asked to the farmer is "If you don't use this practice [listed in the question] currently, would you adopt the practice if you were given a $[X] payment per acre?" (answer 'yes' or 'no').[19] The sample selection equation is "Is this practice [listed in the survey] currently in use on your farm?" (answer 'yes' or 'no').

The pool of variables from which the explanatory variables were drawn is:

EDUC — Formal education of operator.
EINDEX — Sheet and rill erosion index.
EXPER — Farm operator's years of experience.
SNT — Soil nitrogen test performed in 1992 (dummy).
TISTST — Tissue test performed in 1992 (dummy).
CTILL — Conservation tillage used in 1992 (dummy).
PESTM — Destroy crop residues for host-free zones (dummy).
ANIMAL — Farm type-beef,hogs,sheep (dummy).
GRAINS — Farm type-cash grains (dummy).
ROTATE — Grasses and legumes in rotation (dummy).
MANURE — Manure applied to field (dummy).
HEL — Highly erodible land (dummy).

Estimation Results

Table 5 presents the weighted probit results for the WTA for adoption questions.[20] The key variable, BID, is of the correct sign and is significant to at least the 1-percent level for all practices except CONTIL, where it is significant at the 5-percent level. However, it was difficult to find significant explanatory power among the explanatory variables. Of the other variables common to all five practices, the coefficient on years of education was significant and positive for two of the five variables. To test for regional differences in the responses, regressions were tried with dummies for the regions but none of the associated coefficients were significant. The difficulty in observing variables that actually factor into the farmer's decision on whether or not to adopt the practice demonstrates the benefits of the stated preferences approach used here over an indirect approach, such as one that relies on estimating a profit function.

Table 6 presents the median WTA per acre estimates for each of the six practices. Weighted univariate probit estimates range from $32 per acre for CONTIL to $57 per acre for MANTST. Standard errors for these estimates using the analytic approach described by Cameron (1991) are presented to the right of each of the values. Plugging the values in the γ and α columns into appendix C's equation (9.1) will yield the WTA values in the first column.

Table 5—Probit results for model for the decision to adopt the environmentally sound management practices (asked of farmers who do not currently use the practice)

Variable	CONTIL	SPHN	LEGSR	MANTST	SMTST
			Coefficient estimates		
CONST	-0.2863	-0.6686**	-1.8774**	-1.5574**	-1.5574**
	(-0.9420)[1]	(-3.0670)	(-7.8970)	(7.4760)	(-7.6660)
BIDVAL	0.0198*	0.0433	0.0303**	0.0269**	0.0324**
	(1.9400)	(5.1090)	(3.3270)	(3.3620)	(4.1570)
EDUC	-0.0666	-0.0308	0.1002*	0.0630	0.0959**
	(-1.2250)	(-0.7420)	(2.2940)	(1.6290)	(2.5420)
CTILL	0.0906	--	--	--	--
	(0.5060)				
HEL	-0.1139	--	--	--	--
	(-0.5750)				
TISTST	--	0.8757*	0.2365	-0.2708	--
		(2.0950)	(0.7650)	(-0.7980)	
EXPER	-0.0079	-0.0133**	-0.0004	-0.0105**	-0.0096*
	(-1.3850)	(-2.9680)	(-0.0910)	(-2.4010)	(-2.2130)
PESTM	0.1869	--	--	--	
	(1.1270)				
ROTATE	0.0306	0.0356	0.4422*	0.3230	0.2034
	(0.0980)	(0.1550)	(1.6920)	(1.5450)	(0.9720)
MANURE	-0.0202	-0.2206	-0.3039	0.3161**	--
	(-0.0900)	(-1.4320)	(-1.5650)	(2.3540)	
ANIMAL	--	0.0742	0.2942*	0.4385**	--
		(0.5740)	(2.1290)	(3.7760)	
Observations	331	683	860	1,101	1,070

[1]Coefficient divided by standard error in parentheses.
* = Significance of 5 percent.
** = Significance of 1 percent.

Table 6—Mean minimum expected willingness to accept (per acre) to encourage use of the practices

Practice	Mean	S.E.	γ	α
	Dollars		*Coefficient*	
CONTIL	31.67	10.38	-0.6275	0.019814
SPHN	25.35	3.14	-1.09664	0.043256
LEGSR	50.96	12.18	-1.54205	0.030255
TISTST	56.59	13.76	-1.52341	0.026919
SMTST	45.76	8.51	-1.48393	0.032432

Model Applications

Given that the WTA estimates necessary to achieve 50 percent adoption are much higher than the current payments levels, it is not surprising that participation in the program by eligible farmers is quite low for many of the practices (table 6). However, given that encouraging participation is not costless, a cost-efficiency or cost-benefit analysis could be used to determine what participation rates, and hence, what offer amounts would be desirable for each practice. To do this, a farmer response function is necessary. As discussed earlier, probit coefficient results can be plugged into the normal CDF to predict probability of adoption of the practices for different incentive payment levels. In conjunction, for those farmers who are predicted to adopt the practice at a given payment level, the continuous equation can be used to predict the number of acres enrolled.

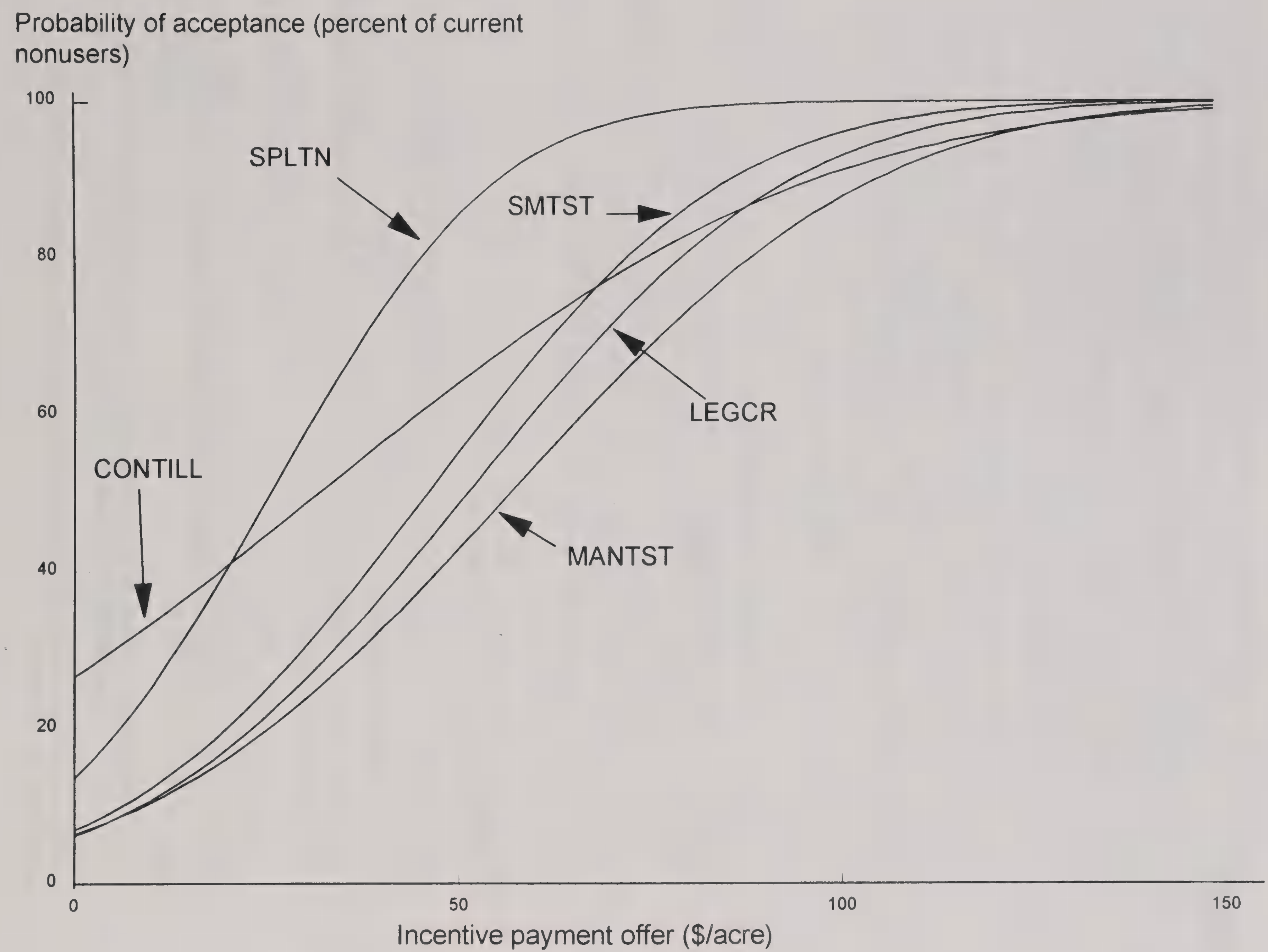
Using the univariate probit coefficients (or the univariate coefficients for CONTIL and SPLTN) for the WTA equation for each of the practices, figure 5 graphs the relationship between the offer amount and the probability of acceptance for those farmers who do not currently use the practices.

These response functions could be used in a mathematical programming model to determine the incentive payments that maximize the net benefits of the incentive payment program, where net benefits are defined as the change in environmental benefits (in dollars) due to the switch to the preferred practices minus the total incentive payment outlays. Further research is needed to put a monetary value on the environmental benefits of the changes in farm management practices.

Implications

Farmers can be encouraged to voluntarily adopt environmentally sound management practices through the use of incentive payments. Current USDA practice is to offer a fixed "take it or leave it" payment per acre to those not currently using the desired practices. Hence, there is insufficient observed data to model the probability of farmer adoption of the environmentally sound management practices as a function of the payment offer. Without this function, one does not know at what level to set incentive payments to achieve desired levels of participation. This case study uses a direct revelation technique based on a random utility model to develop and estimate models predicting farmer adoption of the practices as a function of the payment offer. These results can be used in a cost-benefit analysis to best decide how to allocate the program budget among the preferred production practices.

Figure 5. Response curves for the subsidized practices



Conclusion

This report has demonstrated that nonmarket valuation techniques have useful applications in examining the relationship between agricultural practices and the environment. In a nontraditional use of nonmarket valuation techniques, this report has presented a case study of an application of referendum CVM to the farm producer side to predict the costs to the government of proposed agricultural policies. Examples of other possible applications of referendum CVM techniques include estimation of the farmer's minimum willingness to accept to encourage the farmer to install filter strips on the farmer's property and the farmer's minimum willingness to accept to encourage participation in the Conservation Reserve Program.

As one may gather from reading this report, CVM is applicable to a much greater range of issues that have agricultural implications than does TCM. TCM requires observed data, in particular, it requires recreational participation data. Furthermore, TCM is only practical for application to recreational sites that are the primary destination of a trip. Since most agricultural issues do not involve recreational opportunities, these two requirements limit TCM's role in assessing the economic impacts of agricultural activities. However, TCM is useful in those cases where a link can be made between recreational trips to a site and agriculturally related impacts at the site.

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Appendix A: Net Benefits Estimation for Zonal Travel Cost Models

If we estimate equation (1) in linear form, then the total net benefits for site j is

$$(3) \qquad CS_j = \sum_{i=1}^{n} \left(POP_i * \int_{TC_{ij}}^{TC_{ij}^{max}} (\beta_0+\beta_1 TC_{ij}+\beta_2 DEMOG_i+\beta_3 QUAL_j+\beta_4 SUBS_i) dTC \right),$$

where TC_{ij}^{max} is the choke price (the travel cost that drives trips from origin i to site j to zero). All the other variables are evaluated observation by observation.

A frequent goal of a TCM study would be to calculate the change in net benefits associated with a change in a qualitative attribute of the site, such as acreage at the site open to recreationists. The incremental change in net benefits at site j for an increase in site quality from $QUAL_0$ to $QUAL_1$ is

$$(4) \qquad \Delta CS_j = \sum_{i=1}^{n} \left(POP_i * \int_{TC_{ij}}^{TC_{ij}^{max}} (\beta_0+\beta_1 TC_{ij}+\beta_2 DEMOG_i+\beta_3 QUAL_1+\beta_4 SUBS_i) dTC \right) -$$

$$\sum_{i=1}^{n} \left(POP_i * \int_{TC_{ij}}^{TC_{ij}^{max}} (\beta_0+\beta_1 TC_{ij}+\beta_2 DEMOG_i+\beta_3 QUAL_0+\beta_4 SUBS_i) dTC \right).$$

Appendix B: Additional Details on the Econometric Specification of Travel Cost Models

Although recreational demand models were traditionally estimated using estimators such as ordinary least squares (OLS), count data regression models such as the Poisson or negative binomial are rapidly supplanting or replacing the use of these older techniques for several reasons (Hellerstein, 1991; Creel and Loomis, 1990). Namely, in recreational demand models, trips are censored at zero. In other words, it is not possible to take negative amounts of trips. Also, trips are not drawn from a continuous distribution -- one cannot take a fraction of a trip. Unfortunately, OLS does not account for the censoring and the integer nature of the dependent variable and may produce biased, and almost certainly, inefficient estimates. Count data models address both the issue of censoring and the integer nature of trips. In addition, some behavioral justifications have been made for the use of count data models (Hellerstein, 1991). But whether or not one agrees with these various behavioral justifications for the use of count data models, these models merit strong consideration for TCM from purely an empirical standpoint.[21]

The Poisson and the negative binomial are the most common distributions used in the count data models, both of which assume a distribution over Prob(TRIPS = trips; trips = 0,1,2,...). The single parameter Poisson distribution has a rather strict assumption that the mean, E(TRIPS), and variance, σ^2(TRIPS), of the distribution are equal. The two parameter negative binomial relaxes this assumption and allows the variance to vary. By doing this, the negative binomial can control for overdispersion of the dependent variable.

The most common functional form for the Poisson parameter and the negative binomial mean is

(5) $\lambda = E(TRIPS) = POP * \exp(\beta_0 + \beta_1 TC + \beta_2 DEMOG + \beta_3 QUALITY + \beta_4 SUBS)$,

where POP, TC, DEMOG, QUALITY, and SUBS are the means of the variables that are defined

below equation (1), and E(TRIPS) is estimated mean trips.[22] The functional form in equation (2) eliminates the possibility of a negative λ. Because aggregate data for a zone of origin are used in the zonal TCM data sets, the populations for the zones of origin must be factored into the model. Using population as a multiplicative weight is suggested by the empirical properties of count data models (Hellerstein, 1991). Given the parameter estimates, the expected number of trips from each county of origin i to each site j is $E(TRIPS_{ij}) = POP_i * \exp(\beta_0 + \beta_1 TC_{ij} + \beta_2 DEMOG_i + \beta_3 QUALITY_j + \beta_4 SUBS_i)$. Among the useful properties of the Poisson and negative binomial are that zero trip values are allowed (with OLS, the log of $TRIPS_{ij}/CAP_i$ is frequently the dependent variable) and that, if a constant is included, the sum of predicted trips across all observations is equal to total actual trips.

The need to acknowledge nonparticipants in TCM should be stressed. To exclude zero value trips (in the aggregate context, all zones of origin do not necessarily display a positive level of trips to all sites) is to exclude important data about nonparticipation from the data set, thereby possibly biasing the results. An advantage of the zonal approach compared to surveys of individuals is that it is simple to include nonparticipants in the data set. If the data sets contain all the recreationists who traveled to the study sites during a 1-year period or during the whole season (such as the ones used for the case studies), the true level of participation, and thus, nonparticipation is known. Truncation bias is avoided by including areas of origin with zero trips in the data set. Since taking the log of the trip variable is avoided with the count data models, unlike with the semi-log OLS models, the count data models easily accept zero trips.

However, even with its drawbacks, an OLS regression is useful for comparative purposes. In the TCM literature, the predominant functional forms chosen for the traditional OLS recreation demand functions are the linear, linear-log, log-linear, and the log-log. The log-linear and the log-log functional forms possess several desirable traits missing from the other commonly used functional forms. Past research has shown that taking the natural log of trips per capita minimizes two problems that arise with a linear model. First, the log of trips per capita eliminates the possibility of predicting negative trips per capita, which can occur with the other functional forms. Second, heteroskedasticity associated with zones of different population sizes is minimized using the log of the dependent variable (Strong, 1983: Vaughan and others,1982). If the log-linear functional form with $\ln(TRIP_{ij}/POP_i)$ as the dependent variable is selected for the OLS regression, one can compare the OLS coefficient estimates to the count data coefficients.[23] Of course, a small constant (such as 0.00001) needs to be added to $TRIP_{ij}$ to allow the inclusion of zero values in the OLS regression.

Other Issues in Benefit Estimation Using TCM

Finally, opinions differ as to whether the estimated demand curve should be forced to pass through actual price and quantity in the net benefits estimation stage. As a base to estimating the site benefits, the second stage demand equation can be calibrated so that the total systematic portion of the demand function runs through actual price (round-trip distance) and observed quantity for each site. The author's opinion is that in order to produce an unbiased estimate of total net benefits per site, it is necessary to have an unbiased estimate of total trips per site. The adjustment factor can be (total estimated base $TRIPS_j$) / (actual $TRIPS_j$), j = 1,...,J sites. This approach consistent in philosophy with the Gum and Martin (1975) procedure of shifting the demand curve through the actual price and quantity. If one assumes, as do Bockstael and Strand (1987), that the TCM equation is subject to omitted variables (that are uncorrelated with the included variables), which is the most plausible scenario, then actual quantity and price should be used in the surplus estimation function. For a dissenting view, see McKean and Revier (1990). For semi-log or double-log demand function specifications, multiplying the estimated demand function by this adjustment does not affect the CS per trip value. When calculating the area under the semi-log second stage demand function, a change in any of the exogenous variables except price will cause total net benefits and estimated trips to move in the same direction and in the same proportion (an increase in site quality is expressed as more trips, with net benefits per trip constant with the semi-log form). Hence, an unbiased estimate of total net benefits can be made by multiplying actual trips by the net benefits per trip.

Appendix C: Derivation of the WTP Measure for Dichotomous Choice CVM

For practical purposes, an individual's true WTP is unknown to the researcher and can be treated as a random variable. Hanemann (1989) noted that the mean of any random variable can be expressed as

$$[6] \qquad E(WTP) = \int_{-\infty}^{\infty} bf(b)db = \int_{0}^{\infty}[1-F(bid)]dbid - \int_{-\infty}^{0} F(b)bd.$$

where F(bid) is the cumulative probability density function (CDF), i.e., Prob(WTP_i <= BID_i). If the random variable is restricted to be nonnegative, then the equation for the mean can be reduced to

$$[6.1] \qquad E(WTP) = \int_{-\infty}^{\infty} bf(b)db = \int_{0}^{\infty}[1-F(bid)]dbid\ .$$

Hanemann's (1984) utility difference model provides a theoretical foundation for deriving the parameters necessary for estimating E(WTP). From the utility theoretic standpoint, an individual is willing to pay \$C for an increase in the quality of an environmental amenity if the individual's utility at the new level of the amenity and lower income is at least as great as at the initial state, if $U(0,y;x) \leq U(1,y - C;x)$, where 0 is the base state; 1 is the state with the increase in the environmental amenity; y is individual i's income; and x is a vector of other attributes of the individual that may affect the WTP decision.[24] An individual's utility function U(i,y;s) is unknown due to components of it that are unobservable to the researcher, and thus, can be considered a random variable from the researcher's standpoint. The observable portion is V(i,y;x), the mean of the random variable U. With the addition of an error ε_i, where ε_i is an i.i.d. random variable with zero mean, the individual's decision to pay \$C can be re-expressed as

$$[7] \qquad V(0,y;x) + \varepsilon_0 \leq V(1,y - C;x) + \varepsilon_1.$$

If $V(i,y;x) = \gamma_i - \alpha y$, where $\alpha < 0$, for i = 0,1, then an individual is willing to pay \$C for the change if $\gamma_0 - \alpha y + \varepsilon_0 \leq \gamma_1 - \alpha(y-C) + \varepsilon_1$.[25]

The decision to pay \$C can be expressed in a probability framework as $\Pr\{WTP \leq \$C\} = \Pr\{V_0 + \varepsilon_0 \leq V_1 + \varepsilon_1\} = \Pr\{\varepsilon_0 - \varepsilon_1 \leq V_1 - V_0\}$, where $V_1 - V_0 = \gamma + \alpha C$, and where $\gamma = \gamma_1 - \gamma_0$. Since $V_1 - V_0 = \gamma + \alpha C$ is generated directly from the utility model given above, it is compatible with the theory of utility maximization. If the logistic cumulative probability density function is applied to this stochastic framework for the utility difference model,

$$[8] \qquad Pr(WTP \leq P) = F_{\varepsilon}(V_1 - V_0) = 1-(1+\exp^{-(V_1-V_0)})^{-1} = 1-(1+\exp^{-(\gamma+\alpha C)})^{-1}.$$

Because the utility difference function can be expressed in this probability framework, the logit regression model can be used to obtain the coefficients estimates.

Once the parameter estimates have been obtained, mean WTP can be calculated by substituting the CDF in equation (8) into equation (6). According to Hanemann (1989), if the CDF in (6) is the logistic, then (6) can be re-written as

$$[9] \qquad E(WTP) = \frac{\gamma}{-\alpha}, \quad where\ \alpha < 0.$$

or equivalently, decomposing γ into the sum of its parts in a multiple regression case (with p explanatory variables) yields

$$E(WTP|\mathbf{x}_0) = \frac{(\gamma_1 x_{0.1} + \gamma_2 x_{0.2} + ... + \gamma_p x_{0.p})}{-\alpha}, \qquad [9.1]$$

where $\mathbf{x}_0$ is a vector of the explanatory variables (excluding the bid variable) evaluated at, say, their means. If WTP is restricted to be nonnegative, equation 6.1 can be rewritten as

$$E(WTP|\mathbf{x}_0) = \frac{\ln(1 + \exp^{(\gamma_1 x_{0.1} + \gamma_2 x_{0.2} + ... + \gamma_p x_{0.p})})}{-\alpha}. \qquad [10]$$

Although Cameron's (1988, 1991) censored logistic method takes a somewhat different approach to deriving the welfare benefit measure, the result is the same as Hanemann's logit approach. McConnell (1990) shows them to be the dual to each other, with the Hanemann model being a difference in utility functions and the Cameron approach being a difference in cost functions. The Cameron approach assumes that the unobserved WTP can be expressed as

$$WTP_i = x_i'\beta + u_i, \qquad [11]$$

where u_i is independently and identically distributed $(0,\sigma^2)$, and where $\mathbf{x}_i$ includes all explanatory variables except the bid variable, which, in this equation, would be endogenous.

Even though WTP_i is unobserved, it is possible to directly estimate β with the censored logistic approach because the bid amount bid_i is separated out from the explanatory variables as follows:

$$\begin{aligned} [12] \qquad \text{Prob}(\text{"YES}_i\text{"}) &= \Pr(WTP_i > bid_i) \\ &= \Pr(u_i > bid_i - x_i'\beta) \\ &= \Pr(u_i/\sigma > (bid_i - x_i'\beta)/\sigma). \end{aligned}$$

$\Pr(u_i/\sigma > (bid_i - x_i'\beta)/\sigma)$ is substituted for Pr(.) in the maximum likelihood function for a qualitative dependent variable model, thus allowing the estimation of β and σ. As an alternative to direct estimation, the coefficients in the Cameron specification can be obtained from a simple transformation of the coefficients from the traditional qualitative dependent variable regression (Cameron, 1991; Duffield and Patterson, 1991). While the mean estimate of WTP will be the same as that in equation 7 (though not 8), the Cameron specification allows the researcher to more easily examine the impact of a change in an explanatory variable on WTP.

Cameron's (1988, 1991) censored logistic method takes a somewhat different approach to deriving the welfare benefit measure, though the result is the same under certain conditions. The Cameron approach assumes that the unobserved WTP can be expressed as

$$WTP_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + ... \beta_k x_{ki} + u_i, \qquad [13]$$

where u_i is independently and identically distributed $(0,\sigma^2)$, and where the $\mathbf{x}_i$'s are the explanatory variables (see Appendix C for a brief discussion of how to estimate β). The estimation technique for equation (3) is similar to logit and the data requirements are the same. Note that the bid variable is not included as an explanatory variable in this equation. Given the coefficient estimates, mean WTP is obtained by substituting the variable means in the righthand side of the above equation. As McConnell (1990) notes, one should not include the respondent's level of use of the good being valued as an explanatory variable as the variable would be endogenous (WTP_i is a function of Quantity of

Use_i and Quantity of Use_i is a function of WTP_i). Survey question design is the same under this approach or the utility difference approach.

Though the logistic regression is the most popular choice for estimating the coefficients for the above models, it is not necessary to assume that WTP has a logistic distribution. Cooper and Loomis (1993) present the use of the Weibull distribution (Weibit), a slightly asymmetric distribution, for estimating the coefficients. However, when distributions other than the logit or normal are used, closed form solutions to equation (6) are generally not available. Thus, the integral in these equations must be estimated numerically.[26] It is not necessary to assume a distributional form. Kristom (1990) presents a nonparametric estimator for the parameters. These parameters are then used to create a survival function, the area under which is the welfare estimate.

Appendix D: Discussion of the Empirical Results in Table 2

The count data models were estimated using the GRBL applications package for the Gauss computer programming language (Hellerstein, 1992b). Unfortunately, the negative binomial model gave spurious results for this data set, with the result that the sum of estimated demand was three times greater than observed demand across all observations. This problem was possibly due to a greater range in the trip variable (which ranged in size from 0 to 2,160 trips) than the negative binomial regression models could empirically handle.[27] The Poisson model was specifically estimated with the pseudo-maximum likelihood approach (PML). The advantage of this approach over ML Poisson estimation is that while both produce consistent estimates of β (assuming E(TRIPS) in equation 4 represents the true mean), PML produces a consistent estimate of the variance-covariance matrix even if E(TRIPS) is not equal to σ^2(TRIPS). The ML estimator, on the other hand, underpredicts the size of the variance-covariance matrix (Gourieroux, Montfort, and Trognon, 1984). The OLS and Poisson regressions results for all the models are found in table 2.

In table 2, all coefficients are of the expected sign and, except for the INCOME coefficient in the Poisson regression, are significant to at least the 5-percent level. H20DEL is significant at the 1-percent level in both regressions. All the OLS coefficients were larger than the Poisson coefficients, with the greatest difference being that for INCOME and the smallest that for H20DEL. The OLS R^2 (equivalent to the $\eta 2$ defined in table 2) falls in the typical range of R^2's for OLS TCM models. With a value of 0.512, the measure of fit for the PML Poisson is relatively high. Note that α, the measure of overdispersion of the dependent variable, is high at 26436, suggesting that the variance of TRIPS is not equal to the mean of TRIPS. In fact, the average variance to mean ratio for TRIPS is 57.96. Because of this overdispersion, the PML Poisson estimator, and not the ML Poisson estimator, is the appropriate estimator. While no out of sample test to compare the two regression models is possible given the available data, because the Poisson model addresses the censored and integer nature of trips (unlike the OLS model) and because the OLS regression results are sensitive to the size of the constant added to the dependent variable, the Poisson results should be considered superior to the OLS results (Creel and Loomis, 1990; Hellerstein, 1991).[28]

Appendix E: Modification of the Utility Difference Model for Determining the Minimum Willingness to Accept to Adopt Environmentally Sound Management Practices

The farmer's decision on whether or not to accept the incentive payment can be modelled with a modification of the random utility model discussed in Appendix C. Because farmer income may fall, or possibly even rise, with participation in the program, the value C in the condition $U(0,y;x) \leq U(1,y + C;x)$ should be rewritten as $C^* + \delta$, where δ is state 0 pecuniary costs less state 1 pecuniary costs. Hence, C can be considered a 'net' incentive payment. Note that δ can be positive; due to some nonpecuniary costs, a farmer may not have switched to the preferred practice even if δ is positive.

As before, using the observed portion of the utility function, the farmer's decision to accept \$C can be re-expressed as

$$V(0,y;x) + \varepsilon^0 \leq V(1,y + C;x) + \varepsilon^1.$$

If $V(i,y;x) = \gamma^i + \alpha y$, where $\alpha > 0$, for $i = 0,1$, then the farmer is willing to accept \$C for the change if $\gamma^0 + \alpha y + \varepsilon^0 \leq \gamma^1 + \alpha(y+C) + \varepsilon^1$. The balance of the description is the same as in Appendix C.

Endnotes

1. The hedonic travel cost and the hedonic property value are other possible approaches to doing nonmarket valuation (see Crutchfield, Feather, and Hellerstein, 1995, for a list of citations). They are less used than the two approaches discussed in the text, and because they are variants of the TCM approach, for space considerations, they will not be discussed further.

2. An example of a nonmarket user good is deer hunting on public land. An example of a nonuse good is the existence value of preserving Spotted Owls in the Pacific Northwest.

3. See Clawson and Knetsch (1966), Dwyer, Kelly and Bowes (1977), Sorg and Loomis (1985), Ward and Loomis (1986), or Sorg (1987) for a discussion of the basic TCM approach.

4. Weak complementarity allows this calculation to be made. This concept says that the marginal value associated with an increase in the quality of a recreational site is zero if the number of trips to that site is zero, i.e., one does not care about a change in quality at a site unless that person visits the site.

5. The notion of weak complementarity (see, e.g., Bocksteal and Kling, 1988 for a definition) allows us to determine the value of the nonmarketed amenity. The notion of weak complementarity such that if the commodity TRIPS is a weak complement (as it should be in equation 1) with QUALITY, then the benefits of improvement in QUALITY can be approximately measured from the demand equation for TRIPS.

6. Alternatively, to calculate net willingness to pay for a specific zone, the per capita curve can be integrated for each zone of origin (place of residence) over the interval between the current distance and the maximum distance that would force trips to less than one. Site benefits would be the population's weighted sum of each zone's net willingness to pay. Burt and Brewer (1971) and Menz and Wilton (1983) demonstrate the equivalence of this approach to the "second stage" approach. Finally, Adamowicz et al. (1989) provide some equations that can be used to estimate consumer surplus.

7. The selection criteria for choosing the maximum added travel cost should be one that drives trips arbitrarily close to zero.

8. Cooper (1993a) presents a method for determining the appropriate range of bids to include in the surveys.

9. One modification is to ask a second referendum question. If the respondent answered "YES" ("NO") to the bid value in the first question, the respondent is prompted to answer a followup question in which the offered bid value is higher (lower) than the bid amount in the first question (Hanemann, Loomis, and Kanninen, 1991). This double-bounded version, which should give a more precise estimate of the welfare benefit, has the same utility theoretic properties as the single-bounded approach. It is most useful in personal interview instruments, and is not practical for mail surveys.

10. Weibit is similar to a logit regression, except that the Weibull distribution is used in place of the logistic distribution. Since WTP data are usually asymmetrically distributed, the asymmetric Weibull distribution may be a more appropriate choice than the logistic distribution.

11. Because this analysis was done before count data models were used for TCM, ordinary least squares was used as the regression model. Also, note that this demand function applies only to counties that demanded at least one application.

12. Data for 1986 were not used as no coot data were collected that year. Also note that no geese breed there.

13. Distance to substitute sites can be included in the regression as a proxy for the price of substitute hunting activities. However, to reduce the level of multicollinearity between RTDIST and the distance to substitute sites and to add information on the relative quality of each of the substitutes, PSBAG is created by dividing distance to the substitute site by the total bag at the alternative. Economic theory suggests that the coefficient on this variable should have a positive sign. This variable also includes NWR's in the Sacramento Valley (Cooper, 1990). Because the refuges tend to lie at similar distances from many of the areas of origin, including the prices of all eleven substitutes as individual variables would generate too much multicollinearity in the regression, thereby lowering the statistical efficiency of the results.

14. As described by Konyar and McCormick, "The model contains 23 regions, the 17 Western states and the 6 Eastern USDA production regions. The crops included in the model are barley, corn, cotton, oats, rice, sorghum, wheat, hay, and soybeans. The endogenous decision variables are: land to allocate to crops at the regional level, participation in the government commodity programs, and irrigation or dryland cultivation. Each activity has a positively sloping supply curve at the regional level...The objective function is the area between linear demand and supply curves. Maximizing the objective function is tantamount to solving the competitive equilibrium problem."

15. For instance, a farmer who does not have any livestock or poultry may not be interested in performing manure testing.

16. While willingness to pay (WTP) questions are considered to be incentive compatible in the referendum format, some capacity for strategic response bias (in both the upper and lower directions) may still exist with WTA questions. However, the referendum format most likely diminishes this bias over the open-ended question format.

17. In addition to developing the farmer participation equation as a function of the offer amount, we may also like to know the amount of acres the farmer will enroll given the decision to participate. To do this, we could use a model that estimates acreage to be enrolled conditional on a 'yes' response to the adoption question. This procedure is beyond the scope of this paper.

18. The survey procedures in place did not allow a more complex allocation of bids. See Cooper (1993) and Kanninen (1993) for other possible survey designs.

19. For conservation tillage, however, the bids were \$4, \$6, \$9, \$12, \$18, and \$24.

20. Because the survey sampled some regions at higher rates than others (noncropland areas were sampled at lower rates than cropland areas), the data were scaled by sampling weights. Multiplying the data by the weights gives greater weight to the observations from the regions with the lower probability of being selected and decreases the weight to the observations from the regions with higher probability of being

selected. For estimation, the weights are multiplied by the sample size divided by the sum of the weights so that the sum of the weights across the observations is the sample size (Greene, 1992).

21. Other possible indirect, revealed preference models include discrete choice models, such as the random utility model (Parsons and Kealy, 1992). Like the count data models, this model also accounts for censored data. However, this method is quite expensive compared to the zonal approach as it requires purpose built surveys.

22. Note that equation (2) is estimated with POP weighting the righthand side, instead of using TRIPS/POP as the dependent variable, as is the case for the OLS model.

23. Of course, the equivalent functional form $TRIPS_{ij} = POP_i * \exp(X_i * \alpha) * \varepsilon_i$ could be estimated directly using nonlinear least squares (NLS), thereby avoiding the need to add a constant term to $TRIPS_{ij}$ in the log-linear model. However, the estimation results with NLS tend to be quite sensitive to the starting values chosen for the coefficients.

24. Using a similar analysis, an individual is willing to accept $C for, say, accepting a decrease in the quality of an environmental amenity if the individual's utility at the new level of the amenity and lower income is at least as great as at the initial state, i.e., if $U(0,y;x) \leq U(1,y + C;x)$.

25. In practice, the parameter γ can be considered to be a grand constant, which is a sum of any number of explanatory variables (except the price variable) times their means.

26. Computer programs for estimating the qualitative dependent variable models and calculating the welfare estimate for several different distributional assumptions are available from the author.

27. Negative binomial estimation was problematic both when using Limdep 6.0 and with the GRBL Gauss program with either maximum likelihood or quasi-generalized pseudo maximum likelihood estimation (QGPML).

28. However, the importance of addressing the integer nature of trips decreases the larger the average trip value as the distribution of trips asymptotically approaches a continuous distribution for all as the size of trips increases. For $\lambda > 9$, the Poisson distribution may be approximated by the normal distribution with mean λ and variance λ (Hastings and Peacock, 1975). Note that the estimator for λ for this data set, the sample mean of trips, is 36.